TABLE 5

Results after CO_2 was expelled

Control (screen not touching the distilled water)	Water P_H+ 7.6
Control (screen not touching the distilled water)	Water P_H+ 7.6
Pan with seedlings (screen or seed not touching the distilled water)	Water P_H+ 8.0
Pan with seedlings (screen or seed not touching the distilled water)	Water P_H+ 8.0
Pan with seedlings (screen and seed touching the distilled water)	Water P_H+ 8.3
Pan with seedlings (screen and seed touching the distilled water)	Water P_H+ 8.2

The experiments with corn seedlings indicate that no acid other than CO_2 were excreted by the roots. The data for corn seedlings shows an exceedingly small increase in the alkalinity of the distilled water when the roots were permitted to decompose in the water. The increase in alkalinity of the one culture, of 65 seedlings of corn in quartz at the end of 7 days, probably indicates the presence of some dead cells that were not apparent. Distilled water, into which only the roots of wheat seedlings extended, showed a very slight increase in alkalinity when the roots had decayed, but when the screen, germinated and ungerminated seeds, and roots were in the water, the increase in alkalinity was slightly greater.

[1] Czapek, F., *Biochemie der Pflanzen*, **2**, 872, 1905.

[2] T. Pfeiffer u. E. Blanck, *Landw. Versuchstat, Berlin*, **77**, 217 (1912).

[3] Kunze, G., Jahrb. wiss. Bot., **42**, 357 (1906).

[4] Czapek, F., Zur Lehre von den Wurzelausscheidungen, *Ibid.*, **29**, 321.

[5] Stocklasa, J., and Ernest, A., *Ibid.*, **46**, 73 (1908).

[6] Breazeale, J. F., and LeClerc, J. A., *Bull. U. S. Dept. Agric. Div. Chem.*, No. 149 (1912). See also Meurer, R., *Jahrb. wiss. Bot.*, **46**, 503 (1909), and Johnson, H. V., *Amer. J. Bot.*, **2**, 250 (1915).

[7] The water was distilled from a glass still (which had been used for some months) without the use of cork or rubber. The first and last parts of the distillate were discarded.

[8] This method was adopted because the indicator must be accurately calibrated by buffer solutions in order to obtain results of any value. Phenolsulphonephthalein is very useful for such investigations.

SPECTROGRAPHIC OBSERVATIONS OF RELATIVE MOTIONS IN THE PLANETARY NEBULAE

By **W. W. Campbell and J. H. Moore**

LICK OBSERVATORY, UNIVERSITY OF CALIFORNIA

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In these PROCEEDINGS, **2**, 129 (1916), we described certain rotation phenomena of the planetary nebula N. G. C. 7009 (R. A. = 20 h. 58 m.), as observed by means of the Mills spectrograph attached to the 36-inch refracting telescope. In the past nine months, as opportunity offered, we have extended this line of investigation to others of the

brighter planetary nebulae. We have employed 3-prism dispersion and cameras either 16 or 32 inches in focal length. The linear dispersions at H_β are respectively 20 and 10 angstroms to the millimeter. Up to the present time thirty-three planetary nebulae have been examined for evidences of rotational effects. These effects manifest themselves by Dopper-Fizeau displacements of the spectral lines with reference to the normal directions of these lines as defined by the lines of the comparison spectra of hydrogen and helium impressed upon the same photographic plates. The general results of this work are briefly summarized below. It is convenient to speak at first of the results as relative motions in the nebulae rather than as rotations, the former being the more general term.

1. Of the 33 planetaries observed, 16 give definite evidence of relative motions, and for 5 others we suspect that the nebular lines are slightly inclined in some cases and distorted in others. For 12 of the 33 observed nebulae no indications of relative motion have been found.

2. Attention should be called to the apparent effect of the size of the nebular images upon the results. For the so-called 'stellar' nebulae, or those whose images are essentially round and less than 5 seconds of arc in diameter, the chances of observing line inclinations or distortions are reduced by two causes: first, our experience with nebulae elliptical in outline has been that the relative motions are most pronounced along the major axes of figure, and in the stellar nebulae the positions of the major axes are unknown; and secondly, the spectral lines from the stellar nebulae are very short. Of the stellar objects only one has certainly shown rotational effects. Seven of the 12 objects mentioned in the preceding paragraph as giving no evidence of relative motion belong to the stellar class.

3. Of the nebulae whose diameters are between 5 and 20 seconds of arc, 7 give certain evidence of relative motion, 3 are suspected and 5 seem to give no evidence.

4. All of the 8 nebulae whose diameters exceed 20 seconds of arc give strong evidence of relative motion.

5. With one or two exceptions, the images of the nebulae in which relative motion has been observed are approximately elliptic in form. The greatest observed effects occur in general with the elliptical forms of greatest eccentricity.

6. The 5 nebulae with diameters between 5 and 20 seconds of arc which show no relative motions are sensibly round, which suggest that the axes of rotation may lie very nearly in the line of sight; in which cases the spectrographic test would not be applicable.

7. About half of the nebulae in which relative motion has been detected give spectral lines of forms and degrees of inclinations which are satisfactorily interpreted as due to fairly rapid rotations of the central parts of the nebulae about axes approximately perpendicular to the longer axes of figure, and slower to rotations of the outer parts of the nebulae. These objects belong in general to the class of smaller planetaries whose diameters are of the order of 10 seconds of arc.

8. Five nebulae, most of which are ring nebulae, give lines which suggest the presence of other form or forms of relative internal motion in addition to those interpretable as rotational.

9. The spectra of 3 of the larger ring nebulae, among them the well-known ring nebula in Lyra, while definitely showing internal motions of considerable magnitude, are apparently not interpretable on a simple rotation hypothesis. If rotation effects exist, they appear to be modified or concealed by some other type of motion whose nature we have not yet determined.

10. The central sections of the lines in the spectra of the ring nebula in Lyra and a few other nebulae, corresponding to the central areas of the nebular images, are of bowed form, convex to the red, and are broadened; the central section of the lines in the spectrum of N. G. C. 7662 (R. A. 23 h. 21 m.) is doubled, with one bowed form convex to the red and the other convex to the violet; and the central section of the lines in the spectra of several nebulae are broadened toward the red. These phenomena, if interpreted as Doppler-Fizeau effects, suggest motion of nebular materials toward the nebular nuclei at the centers of the objects, but the high values of the corresponding velocities make the acceptance of such an idea difficult. However, the hypothesis should at least be given careful consideration.

11. The observations indicate that in the nebulae which are more and more condensed as the center is approached we seem to be dealing with simple cases of rotating bodies whose outer strata rotate more slowly both linearly and angularly than the strata nearer the center. In other nebulae, of the ring form with central nuclei, rotation effects seem to be combined with motions of other nature.

12. Measures of the rotational velocity of a nebula enable us to draw some interesting conclusions concerning its probable mass. Assuming that a particle in a nebula at a given angular distance from the center is moving in obedience to the gravitational force of the central mass, then, if the central mass is assumed to be equal to the mass of our Sun, the maximum distances of 9 nebulae whose relative motions seem to be interpretable as rotations lie between 250 light years and 5

light years. These are improbably small distances. If we assume that these nebulae are at distances of 1000 light years, which we have reason to believe is of the order of more probable distance, the minimum values of their masses, in terms of the Sun's mass, lie between 4 and 210.

13. As explained in the former paper, it is difficult to avoid the conclusion that the so-called ring nebulae are in reality not ring forms in space, but ellipsoidal shells. If these forms are rotating about the minor axis of figure, which also seems highly probable, it is difficult to account for their apparent equilibrium under rotational and gravitational forces: it would seem that the nebular materials in the polar regions—the regions of the extremities of the rotation axes—should be depressed toward the central nuclei. Are other forces, possibly including radiation pressure, involved?

14. Inasmuch as the observer will not in general be situated in the planes of the equators of rotation of the nebulae, the observed rotational velocities are smaller than their true values. On this account the actual masses of the observed nebulae should be greater than the minimum values assigned above. The effect of radiation pressures would likewise make the deduced masses too small. The indications are that the nebulae under consideration are capable of developing into systems much more massive than is our solar system.

NEW DETERMINATIONS OF PERMEABILITY

By S. C. Brooks

LABORATORY OF PLANT PHYSIOLOGY, HARVARD UNIVERSITY

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The purpose of these experiments was to investigate permeability by new and independent methods, in order to test as far as possible the conflicting views now held by different investigators. For a number of reasons the investigation was confined to electrolytes.

1. A new method of determining permeability was devised, which is independent of other methods. This consists in direct measurements of the rate of diffusion of dissolved salts through a diaphragm of tissue from the thallus of *Laminaria Agahrdii* (formerly identified as *L. saccharina*). Discs of tissue (*E*, fig. 1) were placed between two short lengths of glass tube (*A* and *B*), the ground ends of which were covered with a suitable grease (*F*), and applied to the tissue in such a manner as to make the joint water-tight. One of these cells was closed at the end away from the diaphragm by a rubber tube and pinchcock (*C* and *D*). The 'lower cell' thus formed was filled with sea water or with a salt solution having